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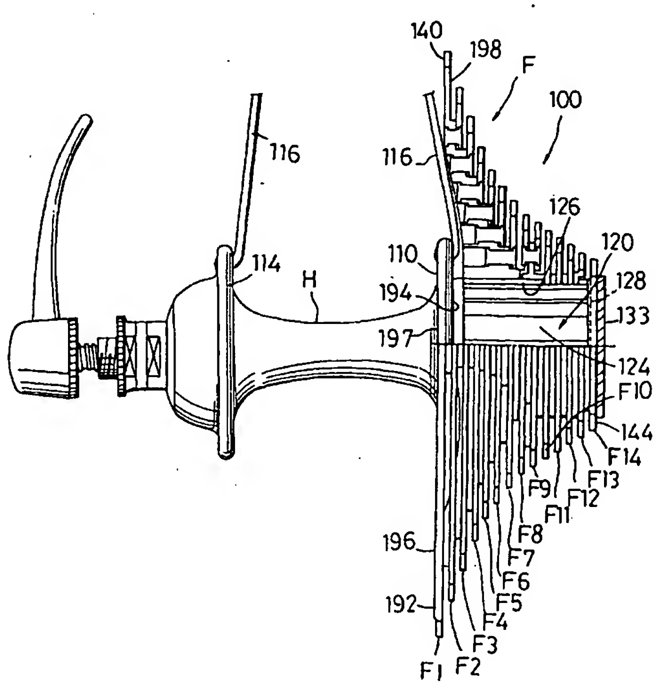
(54) Multiple sprocket assembly for a bicycle

(57) A plurality of sprockets (F_1 to F_{14}) are coaxially mounted together, wherein a spacing between each pair of adjacent sprockets is less than a thickness of at least one of the plurality of sprockets (F_1 to F_{14}). In another embodiment of the invention, a plurality of sprockets (F_1 to F_{14}) are coaxially mounted together, wherein a spacing between each pair of adjacent sprockets is less than or equal to approximately 2.0 millimeters. In yet a further embodiment of the present invention, at least ten sprockets are coaxially mounted together to form a first free side sprocket surface (144) facing laterally outwardly and a second free side sprocket surface (140) facing laterally inwardly. A spacing between the first free side sprocket surface (144) and the second free side sprocket surface (140) is less than or equal to approximately 50 millimeters.

FIG.12



EP 0 849 155 A2

Description

BACKGROUND OF THE INVENTION

The present invention is directed to bicycle drive mechanisms and especially, but not exclusively, to a multiple sprocket assembly for a bicycle which includes a large number of freewheel sprockets.

Figure 1 is a diagram illustrating a typical bicycle drive mechanism. As shown in Figure 1, crank arms 1 having pedals 3 are rotatably coupled to a bicycle frame 2. A chainwheel assembly C comprising a plurality of sprockets, for example, C1 and C2, are connected to crank arms 1 so that rotating pedals 3 in a circular manner causes sprockets C1 and C2 to rotate together with crank arms 1. A freewheel assembly F comprising a plurality of sprockets F1, F2, etc. are mounted to the rear wheel of the bicycle (not shown), and a chain 4 selectively engages one of the chainwheel sprockets and one of the freewheel sprockets. A front derailleur 5 having a chain guide 6 is provided to switch the chain among the plurality of chainwheel sprocket, and a rear derailleur 7 having a guide pulley 8 and a tension pulley 9 is provided to switch the chain among the plurality of freewheel sprockets.

It is desirable to increase the number of sprockets, particularly in the rear freewheel, to provide the bicyclist with a greater choice of gears. However, the amount of lateral space in which to mount the chainwheel and/or freewheel is limited by the design of the bicycle and accepted design standards. Thus, in order to fit more sprockets into the available space, it is usually necessary to decrease the spacing between the adjacent sprockets. On the other hand, the minimum spacing between adjacent sprockets is limited by the width of the chain.

Figure 2 is a top view of a segment of the conventional chain 4. A typical chain has pairs of outer links 10A and 10B which alternate with pairs of inner links 11A and 11B, wherein each pair of outer links 10A and 10B is connected to a corresponding pair of inner links 11A and 11B using a press-fit connecting pin 12. More specifically, the ends of each outer link 10A and 10B and the ends of each inner link 11A and 11B have openings for receiving connecting pin 12 therethrough. The corresponding ends of one pair of outer links 10A and 10B are aligned with the ends of an associated pair of inner links 11A and 11B, with the inner links 11A and 11B disposed laterally inwardly of the outer links 10A and 10B, so that the openings in the ends are aligned with each other. The ends of inner links 11A and 11B include flange sections 11C and 11D which abut each other and define the openings of inner links 11A and 11B. A roller 13 is disposed between the pair of inner links 11A and 11B and is rotatably supported by flange sections 11C and 11D. The connecting pin 12 passes through the opening in each link end 10A, 10B, 11A and 11B such that the connecting pin 12 is press fit in the outer link ends 10A and 10B.

The lateral width of a typical chain 4 thus equals the top width of two outer links 10A and 10B plus the top width of two inner links 11A and 11B plus the width of the roller 13 (which is approximately equal to the width of the flange sections 11C and 11D). As a result, the number of sprockets in the multiple freewheel assembly is limited accordingly. More specifically, the minimum spacing between adjacent sprockets is equal to the thickness of one inner chain plate plus the thickness of one outer chain plate plus the thickness of the laterally projecting portion of the connecting pin plus a small free area to avoid binding of the chain, the sum of which is approximately equal to 2.8 millimeters.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a sprocket cluster in accordance with Claim 1.

According to a second aspect of the present invention, there is provided a sprocket cluster in accordance with Claim 3.

According to a third aspect of the present invention, there is provided a sprocket cluster in accordance with Claim 5.

According to a fourth aspect of the present invention, there is provided a multiple sprocket assembly in accordance with Claim 7.

According to a fifth aspect of the present invention, there is provided a bicycle hub and sprocket apparatus in accordance with Claim 14.

According to a sixth aspect of the present invention, there is provided a chain and a sprocket cluster in accordance with Claim 22.

A preferred embodiment of the invention provides a bicycle drive mechanism which includes a large number of freewheel sprockets, for example, ten or more and preferably fourteen freewheel sprockets. A very narrow chain may be used with the freewheel sprocket cluster to maximise the number of sprockets which can be mounted together.

In one embodiment of the present invention, a plurality of sprockets are coaxially mounted together, wherein a spacing between each pair of adjacent sprockets is less than a thickness of at least one of the plurality of sprockets. In another embodiment of the invention, a plurality of sprockets are coaxially mounted together, wherein a spacing between each pair of adjacent sprockets is less than or equal to approximately 2.0 millimeters. In yet a further embodiment of the present invention, at least ten sprockets are coaxially mounted together to form a first free side sprocket surface facing laterally outwardly and a second free side sprocket surface facing laterally inwardly. A spacing between

the first free side sprocket surface and the second free side sprocket surface is less than or equal to approximately 50 millimeters.

In preferred embodiments, the sprocket cluster may include a mounting member having a plurality of arms radially extending from a centrally located boss. A first sprocket may be formed as one piece with the mounting member and disposed at the radially outward ends of the plurality of radially extending arms, and a plurality of second sprockets may be mounted to the plurality of radially extending arms coaxially with the first sprocket. If desired, the mounting member may include a plurality of ledges, wherein each second sprocket is mounted on one of the plurality of ledges. A plurality of third sprockets may be mounted to the mounting member so that the third sprockets extend laterally outwardly relative to an outer lateral side surface of the boss. The boss also may include an inner lateral side surface disposed laterally outwardly relative to the first sprocket so that the sprocket cluster may be mounted to a hub such that at least the first sprocket is positioned laterally inwardly of an outer side surface of one of the hub flanges.

The sprocket cluster may be used together with a very narrow chain which accommodates the narrow spacing of the sprockets. Such a chain may include a plurality of intermediate links, a plurality of pairs of outer links, and a plurality of fasteners. Each fastener connects an end of one of the plurality of intermediate links between a corresponding pair of outer links so that the plurality of intermediate links alternate with the plurality of pairs of outer links. Each intermediate link defines a recess between each end thereof for receiving a sprocket tooth therein so that each intermediate link performs the function normally performed by the roller and corresponding pair of inner links in a conventional chain.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram illustrating a typical bicycle chain drive mechanism;
Figure 2 is a top view of a typical bicycle chain;
Figure 3 is a side view of a particular embodiment of a bicycle chain used with a sprocket cluster according to the present invention;
Figure 4 is a top view of the bicycle chain shown in Figure 3;
Figure 5 is a side view of the bicycle chain shown in Figure 3 engaging a sprocket;
Figure 6 is a detailed view showing how the bicycle chain shown in Figure 3 engages a freewheel sprocket;
Figure 7 is a detailed view showing how the bicycle chain shown in Figure 3 engages a chainwheel sprocket;
Figure 8 is a detailed view illustrating an embodiment of derailleur guide and tension pulleys which may be used with the chain shown in Figure 3;
Figure 9 is a top view of an alternative embodiment of an intermediate link which may be used in the bicycle chain;
Figures 10A and 10B are side and rear views, respectively, of another alternative embodiment of an intermediate link which may be used in the bicycle chain;
Figure 11 is a top view of another alternative embodiment of an intermediate link which may be used in the bicycle chain;
Figure 12 is a rear view of a particular embodiment of a sprocket cluster according to the invention attached to a hub;
Figure 13 is a side view of a particular embodiment of the sprocket cluster shown in Figure 12;
Figure 14 is an exploded view of the sprocket cluster shown in Figure 12;
Figure 15 is a side view of a particular embodiment of a mounting member used in the sprocket cluster shown in Figure 12; and
Figure 16 is a partial cross sectional view of the mounting member shown in Figure 15.

DETAILED DESCRIPTION OF THE EMBODIMENTS

SPROCKET CLUSTER

Figure 12 is a partial cross sectional rear view of a particular embodiment of a multiple sprocket cluster 100 according to the invention. In this embodiment, sprocket cluster 100 includes at least ten, e.g., fourteen sprockets F_1 through F_{14}. Sprocket cluster 100 is part of freewheel assembly F which, in turn, is part of a hub assembly H. Hub assembly H includes flanges 110 and 114, both of which are connected to spokes 116 in a known manner. Spokes 116 connect the hub assembly to a wheel rim (not shown). In this embodiment, freewheel assembly F includes a mounting cylinder 120 having splines 124 on an outer peripheral surface thereof for engaging corresponding splines 126 formed on the inner peripheral surfaces of sprocket cluster 100, and a free end of mounting cylinder 120 includes a threaded portion 128 on an inner peripheral surface thereof which engages a threaded outer peripheral surface 132 of a lock ring 133 to fix sprocket cluster 100 on mounting cylinder 120.

In this embodiment, sprocket cluster 100 has a total width of less than or equal to approximately 50 millimeters. More specifically, sprocket cluster 100 has a total width of less than or equal to approximately 47 millimeters, such as 46.42 millimeters, between a free side 140 of sprocket F_1 and a free side 144 of sprocket F_{14}. This may be accomplished

in part by forming some, if not all, of the sprockets F_1-F_{14} with a thickness less than or equal to approximately 2 millimeters (at least the outer peripheral portions thereof, if not the entire sprocket). In this embodiment, sprockets F_1-F_{14} may have a thickness less than or equal to approximately 1.8 millimeters, such as 1.76 millimeters. Sprocket F_{14} may be formed thicker than the other sprockets to accommodate the forces resulting from high speed operation of the bicycle. Furthermore, a spacing between adjacent pairs of sprockets may be, for example, less than the thickness of at least one of the sprockets F_1-F_{14}. Between a larger diameter sprocket and a smaller diameter sprocket, the spacing may be measured between the root circle of the smaller diameter sprocket (e.g., at the area labeled R in Figure 13) and the axially aligned portion of the larger diameter sprocket. The spacing also could refer to the portions of the smaller diameter sprocket above the root circle and the axially overlapping portions of the larger diameter sprocket. In this embodiment, a spacing between each pair of adjacent sprockets (using at least one of the two methods) is less than the thickness of each sprocket F_1-F_{14} , and it may be, for example, 1.66 millimeters. The minimum spacing is limited by the thickness of the outer link of the chain which, in this embodiment, is 0.9 millimeters. Regardless ofthe measurement method employed, there is at least some free space (e.g., 0.9 millimeters) between the root circle portions R of the smaller diameter sprocket and the axially aligned portion of the larger diameter sprocket.

Figure 13 is a side view of sprocket cluster 100. In this embodiment, sprockets F_1-F_{14} are structured and positioned according to the teachings of USP 4,889,521, which is included as Appendix 1 hereto. That is, a center point O_1 between a pair of adjacent teeth on a smaller sprocket and a center point O_2 between a pair of adjacent teeth on the next larger sprocket, positioned on an approximate tangent extending along a chain path when a chain is being shifted from the smaller diameter sprocket to the larger diameter sprocket, is equal to an integer multiple of the chain pitch. Furthermore, chain guide portions 150 are provided at the inside surface of the larger diameter sprocket at a position along the chain path between the center points O_1 and O_2. Many such structures are provided on the various sprockets F_1-F_{14}.

Figure 14 is an exploded view of cluster 100 showing how sprocket cluster 100 comprises three sub-clusters 160, 164 and 168. Sub-cluster 160 includes sprockets F_1-F_7; sub-cluster 164 includes sprockets F_8-F_9, and sub-cluster 168 includes sprockets F_{10}-F_{14}.

Sub-cluster 160 includes a mounting member 172 that is shown more clearly in Figures 15 and 16. Mounting member 172 includes a boss 176 having an inner lateral surface 180 and an outer lateral surface 184. As used herein, the terms "inner lateral" and "outer lateral" are defined according to the views shown in Figures 12 and 16, wherein the inner lateral direction is located toward the center of hub assembly H in Figure 12. A plurality, e.g., four, arms 188 extend radially outwardly from boss 176 in a laterally inward direction as shown in Figures 14 and 16. In this embodiment, sprocket F, is formed as one piece with mounting member 172 and is disposed at the radially outward ends of the arms 188. Sprocket F_1 includes a thickened portion 192 located below side 140 to strengthen the sprocket and provide additional rigidity to mounting member 172. Thickened portion 192 may be, for example, 2.5 millimeters. Each arm 188 includes a plurality of ledges 200, wherein each sprocket F_2-F_7 is mounted on a corresponding ledge 200 and is secured to mounting member 176 through bolts or rivets 204 (Figure 14). Splines 126A are formed on the inner peripheral surface of boss 176 for engaging splines 124 on mounting cylinder 120.

As shown more clearly in Figure 16, mounting member 172 has a generally concave cross sectional shape such that inner lateral surface 180 of boss 176 is disposed laterally outwardly relative to a lateral inner surface 196 of the thickened portion 192 of sprocket F_1. Thus, when sprocket cluster 100 is mounted to hub assembly H, sprocket F_1 may be located laterally inwardly of an outer side surface 194 of hub flange 110 as shown in Figure 12. If desired, the entire hub flange 110 may be disposed laterally outwardly of the lateral inner surface 196 of thickened portion 192, or else an inner side surface 197 of hub flange 110 may be aligned with the lateral inner surface 196 of thickened portion 192. If so, the concave portion of mounting member 172 may be shaped so as not to interfere with spokes 116.

Sub-cluster 164 includes a mounting member 210 having a boss 214 and radially extending arms 218. Unlike arms 188 in mounting member 172, arms 218 extend radially straight outward. Sprockets F_8 and F_9 are mounted to arms 218 through bolts or rivets 220. Splines 126B are formed on the inner peripheral surface of boss 214 for engaging splines 124 on mounting cylinder 120 so that sprockets F_8 and F_9 are disposed laterally outwardly of the outer lateral surface 184 of mounting member 172.

Sub-cluster 168 comprises sprockets F_{1o}-F_{14}, wherein sprockets F_{10}-F_{12} are separated from each other through spacers 222 and 224. Splines 126C are formed in the inner lateral surfaces of sprockets F_{10}-F_{14} and spacers 222 and 224 for engaging splines 124 on mounting cylinder 120. Sprocket F_{13} includes a laterally bent portion 228 which separates the radially extending portion of sprocket F_{13} from sprocket F_{12}, and sprocket F_{14} includes a laterally bent portion 232 which seats within the laterally bent portion of sprocket F_{13} and separates the radially extending portion of sprocket F_{14} from sprocket F_{13}.

CHAIN

Figure 3 is a side view, and Figure 4 is a top view, of a particular embodiment of a bicycle chain 15 which may be used with sprocket cluster 100. As shown in those figures, bicycle chain 15 includes a plurality of intermediate links

14, a plurality of pairs of outer links 18A and 18B, and a plurality of fasteners (e.g., connecting pins) 22. Each fastener 22 connects an end of one of the plurality of intermediate links 14 between a corresponding pair of outer links 18A, 18B so that the plurality of intermediate links 14 alternate with the plurality of pairs of outer links 18A, 18B. In this embodiment, each intermediate link 14 is a single solid member having a generally uniform width W, wherein the width W of each end of the plurality of intermediate links 14 defines a spacing between its corresponding pair of outer links 18A, 18B. Preferably, the width W of each end is approximately equal to a thickness S of the engaged sprocket tooth. Furthermore, a cross sectional thickness T of each intermediate link is greater than the width W of the link. Thus, each intermediate link 14 has a generally thin and flat plate shape. In this embodiment, there are no other structures disposed between the ends of the intermediate links 14 and the ends of the corresponding pair of outer links 18A and 18B. In fact, the entire chain 15 is made up of only the intermediate links 14, the pairs of outer links 18A, 18B and the fasteners 22 as shown. The ends of the intermediate links 14 may contact the ends of the corresponding pair of outer links 18A, 18B, or there may be a small space between the ends of the intermediate links 14 and the ends of the corresponding pair of outer links 18A, 18B.

The outer link plates 18A and 18B are thin plates which are spaced apart from each other to define a space 19 for receiving a sprocket tooth therein. Outer link plate 18A includes a laterally curved intermediate portion 20A which curves away from outer link plate 18B, and outer link plate 18B includes a similar laterally curved intermediate portion 20B which curves away from outer link plate 18A. Laterally curved portions 18A and 18B help the sprocket tooth catch the chain during shifting.

As shown in Figures 3 and 5, each intermediate link 14 defines a recess 26 between each end thereof for receiving a sprocket tooth therein. Figure 5 shows the example of chain 15 engaging a tooth 30 of a freewheel sprocket F_n (e.g., sprocket F_{14} of sprocket cluster 100), but the same applies when the chain engages one of the chainwheels. In this embodiment, recess 26 extends between the fasteners 22 at each end of the intermediate link 14 such that a phantom line L connecting the fasteners 22 at each end of each intermediate link 14 (e.g., the center point of each fastener) intersects the recess 26 therebetween. This allows each connecting pin 22 to be sandwiched between adjacent pairs of sprocket teeth. To accommodate recess 26 without compromising the strength of the link, the upper surface 32 of each intermediate link may be convex shaped.

Figure 6 is a detailed view showing how the bicycle chain 15 engages a freewheel sprocket F_n, and Figure 7 is a detailed view showing how the bicycle chain 15 engages a chainwheel sprocket C_n. Because of the position of recess 26 relative to the ends of each intermediate link 14, drive faces 34 and 36 are formed at each intermediate link 14. Since the rear wheel of the bicycle resists the drive force of the chain, drive faces 34 of each intermediate link 14 press against the rear surface of each freewheel sprocket tooth 30 as shown in Figure 6. This resistance, in turn, causes chain 15 to resist the rotation of the chainwheels. As a result, the front face of each chainwheel tooth 40 presses against drive faces 36 as shown in Figure 7. Drive faces 34 and 36 thus perform the function performed by the roller in conventional chains. Also, since each fastener 22 is sandwiched between pairs of adjacent sprocket teeth, stable contact of each drive face and reliable driving of the chain is obtained. To further enhance the performance of the chain, drive faces 34 and 36 may be contoured to match the rear and front surfaces, respectively, of the teeth they contact.

Figure 8 is a detailed view illustrating an embodiment of a derailleur guide pulley 44 and a derailleur tension pulley 48 which may be used with chain 15. Tension pulley 48 may be constructed in the usual way such that a tension pulley tooth 52 projects into each space between adjacent fasteners 22 in chain 15. However, because each intermediate link 14 in this embodiment has a convex surface 32 which does not accommodate sprocket teeth, guide pulley 44 has fewer sprocket teeth 56 so that sprocket teeth 56 project only into the space defined by each pair of outer links 18A and 18B. Guide pulley 44 has convex surfaces 60 for receiving the concave surfaces 32 of the plurality of intermediate links 14.

Figure 9 is a top view of an alternative embodiment of an intermediate link 14 which may be used in bicycle chain 15. In this embodiment, a middle portion 60 of each link 14 is wider than the end portions to increase the strength of the link.

Figures 10A and 10B are side and rear views, respectively, of another alternative embodiment of an intermediate link 14 which may be used in bicycle chain 15. In this embodiment, a rib 64 projects laterally from a middle portion 68 of each link 14 to increase the strength of the link.

Figure 1 is a top view of another alternative embodiment of an intermediate link 14 which may be used in bicycle chain 15. In this embodiment, intermediate link 14 comprises a plurality of intermediate link plates 14A, 14B and 14C. The number of link plates may be varied according to the application.

While the above is a description of various embodiments of the present invention, further modifications may be employed without departing from the spirit and scope of the present invention. For example, the size, shape and orientation of the components may be changed as desired. Sprocket F_1 may be formed separately from mounting member 172, and different types of fasteners may be used in chain 15. Mounting member 172 could be formed as a frustoconical disc, and the thickness of each sprocket in sprocket cluster 100 may be nonuniform. There may be a thin friction bushing between the ends of the intermediate links 14 and the ends of the corresponding pair of outer links 18A and

18B, and the intermediate link 14 need not have a convex upper surface. One of the drive faces 34 or 36 of chain 15 may be omitted. The teeth in sprocket cluster 100 may be modified as desired and may include reduced height teeth or omitted teeth. Thus, the scope of the invention should not be limited by the specific structures disclosed. Instead, the true scope of the invention should be determined by the following claims. Of course, although labeling symbols are used in the claims in order to facilitate reference to the figures, the present invention is not intended to be limited to the constructions in the appended figures by such labeling.

Appendix 1

UNITED STATES PATENT

Nagano

Patent Number:	**4,889,521**
Date of Patent:	**Dec. 26, 1989**

MULTISTAGE SPROCKET ASSEMBLY FOR A BICYCLE

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Primary Examiner:	Thuy M. Bui
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MULTISTAGE SPROCKET ASSEMBLY FOR A BICYCLE

FIELD OF THE INVENTION

The present invention relates to a multistage sprocket assembly for a bicycle, and more particularly, to a multistage sprocket assembly for a bicycle, which comprises at least one larger diameter sprocket and at least one smaller diameter sprocket and is mounted on a crank or a rear hub of the bicycle so as to shift a driving chain for changing the bicycle speed.

BACKGROUND OF THE INVENTION

Conventionally, this kind of multistage sprocket assembly, as disclosed in Japanese Utility Model Publication Gazette No. Sho 55-28,617 (corresponding to US Pat. No 4,268,259), includes a smaller diameter sprocket and a larger diameter sprocket assembled such that (1) the center point between a pair of adjacent teeth at the larger diameter sprocket and the center point between a pair of adjacent teeth at the smaller diameter sprocket are positioned on the tangent extending along the chain path, (2) a distance between the aforesaid center points is an integer multiple of

the chain pitch, and (3) a first tooth of the larger diameter sprocket positioned behind the center point between the adjacent teeth at the larger diameter sprocket in the rotation direction for driving the bicycle is made to be easily engageable with the driving chain, thereby improving the speed change efficiency when the driving chain is shifted from the smaller diameter sprocket to the larger diameter sprocket.

The driving chain comprises a large number of pairs of inner link plates, pair of outer link plates and pins, connected in an endless manner. An interval between the opposite surfaces of each pair of inner link plates is smaller than that between the opposite surfaces of each pair of outer link plates. In other words, each pair of the outer link plates is positioned outside the inner link plates and form a space larger in width, while each pair of the inner link plates is positioned inside the outer link plates and form a space smaller in width.

The driving chain constructed as described above is biased by a derailleur toward the larger diameter sprocket so as to be shifted thereto from the smaller diameter sprocket. During shifting, when the outer link plates of the chain correspond to the first tooth of the larger diameter sprocket, since the first tooth is the easily-engageable tooth and coincides with the chain pitch, the wider space between the outer link plates is at most fitted onto the first tooth, whereby the chain engages with the larger diameter sprocket. Even when the outer link plates correspond to the first tooth as described above, the end face of a link pin and the outer surface of the outer link plate interfere with the inside surface of the larger diameter sprocket

facing toward the smaller diameter sprocket side, so that the chain may not be moved further toward the outside surface of the larger diameter sprocket, such that it will not reliably engage with the first tooth.

On the other hand, when the inner link plates correspond to the first tooth of the larger diameter sprocket, the outer link plate outside the inner link plate, in turn at the larger diameter sprocket side, interferes with the inside surface of the large diameter sprocket, whereby the inner link plate does not deviate sufficiently toward the first tooth, with the result that the space between the inner link plates is not engageable with the first tooth.

In this case, when a second tooth adjacent to the first tooth and behind in the driving rotation direction of the sprocket is made easily engageable like the first tooth, a space between the pair of outer link plates behind the inner link plates in the traveling direction thereof engages with the second tooth. However, the inner link plates behind the aforesaid outer link plates may not engage with a third tooth adjacent to the second tooth and behind in the driving rotation direction, so that even when the space between the outer link plates engages well with the second tooth, the chain may fail to engage with the third tooth and ride thereon, resulting in the chain possibly disengaging from the larger diameter sprocket.

This problem can be solved by making the third tooth easily engageable like the first and second teeth. On the other hand, in a case where the outer link plates are biased in the position at which they correspond to the first tooth, the next outer link plates corresponding to the third tooth may be caught thereby.

In this case, the third tooth is not positioned corresponding to an integer multiple of the chain pitch, so that it will not smoothly engage with the chain. Hence, the outer link plates caught by the third tooth may ride on the edge of the tooth crest thereof and forcibly engage therewith, thereby creating a problem in that the speed change efficiency is diminished and also in that loud sounds are generated due to the chain suddenly falling down onto the tooth bottom.

SUMMARY OF THE INVENTION

An object of the invention is to provide a multistage sprocket assembly for a bicycle which solves the above described problems in the conventional sprocket assembly. According to the invention, the center point between a pair of adjacent teeth at the smaller diameter sprocket and the center point between a pair of adjacent teeth at the larger diameter sprocket are positioned on the tangent line extending along a moving path of the chain when the chain is being shifted from the smaller diameter sprocket to the larger diameter sprocket and a distance between these center points is an integer multiple of the chain pitch, so that the chain is adapted to always smoothly shift from the former sprocket to the latter.

The multistage sprocket assembly of the invention comprises at least one larger diameter sprocket and at least one smaller diameter sprocket, wherein the sprockets are assembled such that the center point between a pair of adjacent teeth at the larger diameter sprocket and center point between a pair of adjacent teeth at the smaller diameter sprocket are positioned on a tangent extending along the moving path of the

driving chain when being shifted from the smaller diameter sprocket engaging therewith to the larger diameter sprocket. The distance between these center points is substantially an integer multiple of the pitch of the chain; and the larger diameter sprocket is provided at its inside surface thereof facing the smaller diameter sprocket and at a position corresponding to the moving path of the chain guide portion allowing the chain to deviate toward the larger diameter sprocket.

In addition, in the present invention, the terminology "distance equal to an integer multiple of the chain pitch" includes the distance between the center points 01 and 02 equal to an integer multiple of the chain pitch and also a distance somewhat smaller than the chain pitch.

Accordingly, in the present invention, the chain, when shifted from the smaller diameter sprocket to the larger diameter sprocket, can be reliably biased a predetermined amount toward the outside surface of the larger diameter sprocket along the chain guide portion provided at the inside surface of the larger diameter sprocket facing the smaller diameter sprocket. Hence, when the outer link plate of the chain corresponds in position to the first tooth positioned behind the center point between a pair of adjacent teeth in the driving rotation direction, the space between the outer link plates can always reliably engage with the first tooth. Moreover, even when the inner link plate corresponds in position to the first tooth, a space between the outer link plates adjacent to and behind the inner link plates in the traveling direction thereof can reliably engage with the second tooth behind the first tooth in the driving rotation

direction of the sprocket.

Also, when the outer link plates engage with the first tooth, the next outer link plates adjacent to the inner link plate behind the former outer link plates in the traveling direction thereof are prevented from riding on a third tooth behind the second tooth in the driving rotation direction of the larger diameter sprocket.

The present invention is further characterized in that at least two teeth among the plurality of teeth of the larger diameter sprocket are speed change teeth with which the chain can easily engage when being shifted from the smaller diameter sprocket to the larger diameter sprocket. These speed change teeth include the first tooth positioned behind the center point between the adjacent teeth at the larger diameter sprocket in the driving rotation direction thereof and one other tooth, with all other teeth of the larger diameter sprocket being formed such that the chain cannot easily engage with them thereby enabling the chain to be shifted to the larger diameter sprocket always at the first tooth thereof in consideration of the relationship with chain pitch. Accordingly, the chain is shifted without mistake and the speed change efficiency is improved.

The present invention is still further characterized in that the speed change teeth include a first tooth, a second tooth, and a third tooth and all other teeth are formed such that they do not easily engage with the chain. Furthermore, the first tooth is provided with a chain guide surface through which the chain, when shifted from the smaller diameter sprocket to the larger diameter sprocket, can be guided in a direction away from the smaller diameter sprocket, that is,

axially outwardly of the larger diameter sprocket, with the second tooth being positioned axially outwardly of the larger diameter sprocket with respect to the first tooth and the third tooth similarly with respect to the second tooth.

Thus, the present invention can improve the speed change efficiency, prevent the outer link plate from being caught by the third tooth, and eliminate generation of sounds when the chain engages therewith.

The above and further objects and novel features of the invention will be more fully apparent from the following detailed description when the same is read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a front view of a first embodiment of a multistage sprocket assembly according to the invention;

Fig. 2 is a partially omitted developed view of Fig. 1 viewed from below;

Fig.3 is a developed view corresponding to Fig. 2, in which a driving chain is shifted at a position different from that in Fig. 2 with respect to the sprockets;

Fig. 4 is a front view of a larger diameter sprocket only;

Fig. 5 is a sectional view taken on line V-V in Fig. 4;

Fig. 6 is a sectional view taken on line VI-VI in Fig. 4;

Fig. 7 is an illustration of another example of a tooth formed to be not easily engageable with the chain;

Fig. 8 is a developed view of a second embodiment of the invention, corresponding to Fig. 2; and

Fig. 9 is a developed view of the Fig. 8 embodiment corresponding to Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

A multistage sprocket assembly of the invention is mounted on a crank or a rear hub of the bicycle.

A first embodiment of the multistage sprocket assembly of the invention in Fig. 1 is mounted on the rear hub of the bicycle, which includes a larger diameter sprocket 1 having 16 teeth at its outer periphery and a smaller diameter sprocket 2 having 13 teeth at its outer periphery, sprockets 1 and 2 being assembled to a driving member (not shown) and spaced from each other at a predetermined interval, the driving member being rotatably supported to a driven member at the rear hub through a bearing.

Also, sprockets 1 and 2 are assembled in a relationship such that the center point 02 between a pair of adjacent teeth at larger diameter sprocket 1 and the center point 01 between a pair of adjacent teeth at smaller diameter sprocket 2 are positioned on a tangent which, as shown by the chain line in Fig. 1, extends along a moving path of a driving chain when shifted from smaller diameter sprocket 2 in engagement therewith to large diameter sprocket 1.

A distance L between centers 01 and 02 is equal to an integer multiple of the chain pitch of chain 3, and a chain guide portion 4 allowing chain 3 to deviate toward larger diameter sprocket 1 is recessed at the inside surface thereof facing smaller diameter sprocket

2 and at the position corresponding to the traveling path of chain 3 when traveling between centers 01 and 02.

Chain guide portion 4 recessed on the inside surface of sprocket 1 is preferably deep enough to prevent the inner link plate of chain 3 at the larger diameter sprocket side from riding on a first tooth 11 at larger diameter sprocket 1, first tooth 11 being positioned behind center 02 at sprocket 1 in the driving rotation direction thereof.

At least two teeth including aforesaid tooth 11 and a tooth 12 adjacent thereto and positioned rearwardly in the rotation direction of sprocket 1 are formed as speed change teeth engageable with chain 3 when shifted from smaller diameter sprocket 2 to larger diameter sprocket 1. The residual teeth except for teeth 11 and 12 are formed as non-easily-engageable teeth through which chain 3 is not shiftable.

Chain guide portion 4 is made large enough to receive therein the link plates of chain 3 positioned at the larger diameter sprocket side, so that chain 3 can deviate a predetermined amount toward outside surface 1b of larger diameter sprocket 1, thereby reliably engaging with first tooth 11. Chain guide portion 4 recessed as described above, is preferably deep enough to engage a space 3a between outer link plates 31 with first tooth 11 when outer link plates 31 corresponds to first tooth 11 as shown in Fig. 2 and to prevent inner link plate 32 of chain 3 from riding on first tooth 11 when inner link plate 32 corresponds to first tooth 11 as shown in Fig. 3. In brief, chain 3 is preferably controlled with respect to its movement with respect to larger diameter sprocket 1.

Chain guide portion 4 may alternatively be formed of a cutout, but when it is recessed, the movement of chain 3 can be controlled and a stepped portion 4a can receive the link plate of chain 3 when shifted.

In the first embodiment in Fig. 1 of larger diameter sprocket 1 of 16 teeth and smaller diameter sprocket 2 of 13 teeth, a distance L between centers 01 and 02 is equal to twice the pitch of chain 3 as shown by the chain line in Fig. 1.

Accordingly, chain guide portion 4 at inside surface 1a of larger diameter sprocket 1 is formed in the size from an initial end edge 4b to a termination 4d at sprocket 1, with initial end edge 4b being somewhat spaced apart from the position corresponding to center 01 between the two adjacent teeth at sprocket 2 and between center 01 and center 02 between two adjacent teeth at sprocket 1, with termination 4d being the tooth bottom between first tooth 11 and a tooth 10 positioned ahead of center 02 in the driving rotation direction (the direction of arrow X) of sprocket 1.

In a condition where outer link plate 31 of chain 31 corresponds to first tooth 11 as shown in Figs. 1 and 2, at chain guide position 4 are positioned inner link plate 32 positioned ahead of outer link plate 31 in the traveling direction (in the direction of arrow Y in Fig. 1) of chain 3, part of an outer link plate 31 positioned ahead of inner link plate 32 in the traveling direction, and a link pin 33 for connecting link plates 32 and 31, with link pin 33 abutting at its end face against bottom 4c of recessed chain guide portion 4.

In a condition where inner link plate 32 corresponds to

first tooth 11 as shown in Fig. 3, at chain guide portion 4 are positioned outer link plate 31 ahead of inner link plate 32 in the traveling direction of chain 3, part of inner link plate 32 positioned ahead of outer link plate 31, and a link pin 33 for connecting link plates 31 and 32, with the end face of link pin 33 and outer link plate 31 abutting against the bottom of recessed chain guide portion 4.

In chain guide portion 4, a depth D1 (in Fig. 6) in a range from an intermediate portion (ie, between initial and 4b and termination 4d) to the termination 4d is made larger than depth D2 (in Fig. 5) in a range from initial end edge 4b to the intermediate portion.

Also, in the first embodiment, a stepped portion 4e is provided at the intermediate portion of guide portion 4 so as to stepwise change the depth thereof, but chain guide portion 4 may alternatively by inclined throughout its entire length.

Since teeth facing chain guide portion 4 each are reduced in thickness to an extent corresponding to the depth of guide portion 4, it is preferable to make these teeth larger in circumferential width than the other teeth as shown in Figs. 1 and 4, thereby restricting the lowering of strength of these reduced-thickness teeth.

All of the teeth except for first and second teeth 11 and 12 are made non-easily-engageable. The non-easily-engageable teeth, as shown in Fig. 2 and 3, are each chamfered at their inner surface facing smaller diameter sprocket 2, or, as shown in Fig. 7, inclined forwardly in the driving rotation direction (in the direction of arrow X) and reversely to smaller diameter

sprocket 2, that is, toward the outside surface of larger diameter sprocket 1 with respect to the center line thickness between inside surface 1a and outside surface 1b of larger diameter sprocket 1, thereby being made difficult to engage with chain 3.

In addition, first and second teeth 11 and 12 are not made non-easily-engageable because chain 3 is intended to reliably engage with first tooth 11, and spaces 3a and 3b between the link plates of chain 3 in engagement with tooth 11 are to reliably engage with second tooth 12, whereby first and second teeth 11 and 12 are preferably easily engageable with chain 3.

Also, a distance between the adjacent teeth and on the pitch circle of respective sprockets 1 and 2 is made larger by a predetermined distance than an outer diameter of a roller of chain 3. Accordingly, distance L between centers 01 and 02 is smaller than an integer multiple of the chain pitch. In other words, when sprockets 1 and 2 are mounted on the rear hub, a driving force from pedaling is transmitted from chain 3 to sprocket 1 or 2, whereby when chain 3 is shifted from sprocket 2 to sprocket 1, the roller at the smaller diameter sprocket 2 side abuts against the rear surface of a tooth ahead of the roller in the driving rotation direction of sprocket 2, and the roller moving toward larger diameter sprocket 1 and caught by the tooth thereof abuts against the front surface of first tooth 11 in the driving rotation direction of sprocket 1, whereby when both sprockets 1 and 2 are aligned, distance L is somewhat smaller than an integer multiple of the chain pitch. In addition, when the distance between the adjacent teeth on the pitch circle corresponds to the outer diameter of the roller, distance L is made equal to an integer multiple of the

chain pitch.

When chain 3 is shifted from smaller diameter sprocket 2 to larger diameter sprocket 1 by a rear derailleur, the engagement of chain 3 with sprockets 1 and 2 will be described in accordance with Figs. 1 through 3.

In Figs. 1 and 3, when chain 3 in engagement with smaller diameter sprocket 2 is displaced by the rear derailleur to larger diameter sprocket 1, chain 3 in part positioned ahead in the driving rotation direction (in the direction of arrow X) remains at smaller diameter sprocket 2 and the same positioned at the rear derailleur operation side reaches the lateral side of sprocket 1 to thereby be inclined and biased toward sprocket 1 as shown in Figs. 2 and 3.

Also, chain guide portion 4 is provided on the traveling path of chain 3 when traveling between centers 01 and 02, so that chain 3 travels a predetermined amount toward the outside surface of sprocket 1, thereby reliably engaging with first tooth 11 thereof.

Since chain guide portion 4 is recessed to an extend such that inner link plate 32 of chain 3 at the larger diameter sprocket 1 side does not ride on first tooth 11, when inner link plate 32 is positioned corresponding thereto, outer link plate 31 abuts against termination 4d of chain guide portion 4 as shown in Fig. 3 and chain 3 is restricted from moving toward the outside surface, thereby preventing inner link plate 32 from riding on first tooth 11.

Also, chain 3 can inevitably engage only with first or second tooth 11 or 12 because all other teeth are non-

easily-engageable teeth, thereby ensuring smooth shifting of chain 3.

Alternatively, as shown in a second embodiment of the invention illustrated in Figs. 8 and 9, a third tooth 13 positioned behind second tooth 12 in the driving rotation direction of sprocket 1 may also not be a non-easily-engageable tooth but rather a speed change tooth engageable with chain 3.

In Figs. 8 and 9, all of teeth 14 except for the first through third teeth 11 through 13 at larger diameter sprocket 1 deviate axially outwardly thereof, that is reversely to sprocket 2, so as to render difficult any engagement thereof with chain 3. First through third teeth 11 through 13 are displaced axially inwardly of sprocket 1, that is, toward sprocket 2, thereby being easily engageable with chain 3. Moreover, first tooth 11 is provided with a chain guide surface 11a for guiding therethrough chain 3 reversely to sprocket 2. Second tooth 12 is displaced reversely thereto with respect to first tooth 11, and likewise third tooth 13 with respect to second tooth 12, so that second tooth 12 is easily engageable with chain 3 subsequently to first tooth 11, with third tooth 13 being not difficult but not-easier to engage with chain 3 than second tooth 12.

In the above-mentioned construction, chain guide surface 11a, as shown in Figs. 8 and 9, is inclined rearwardly in the driving rotation direction of larger diameter sprocket 1 and reversely to smaller diameter sprocket 2 with respect to the center line of thickness of sprocket 1. Alternatively, chain guide surface 11a may be formed such that first tooth 11 is parallel to the aforesaid center line and cutout at a portion

disposed rearward in the driving rotation direction of sprocket 1 and facing smaller diameter sprocket 2, for example, at a portion from the bottom to the crest of the tooth.

When chain 3 is shifted from smaller diameter sprocket 2 to larger diameter sprocket 1, space 3a between outer link plates 31 first engages with first tooth 11. Therefore, first tooth 11 is made to be most easily engageable with chain 3. Second tooth 12 is also made such that it can easily engage with chain 3; this is made possible by providing a narrow space 3b between inner link plates 32 behind wide space 3a. Narrow space 3b is easily engageable with second tooth 12, and, when inner link plates 32 are biased at the position corresponding to first tooth 11 and first tooth 11 cannot catch space 3a, second tooth 12 is adapted to catch space 3a. Also, when second tooth 12 catches wide space 3a, narrow space 3b adjacent thereto is adapted to easily engage with third tooth 13, such that third tooth 13 is made easily engageable with chain 3.

In addition, the displacement of third tooth 13 toward smaller diameter sprocket 2 is reduced more than that of second tooth 12 because, when inner link plates 32 are biased at the position corresponding to second tooth 12 so that first and second teeth 11 and 12 cannot catch wide space 3a, the outer link plate is prevented from riding on third tooth 13.

In the above-described construction, in a condition in which chain 3 is shifted from smaller diameter sprocket 2 to larger diameter sprocket 1, when first tooth 11 corresponds to outer link plate 31, a distance between centers 01 and 02 of an interval between the two

adjacent teeth at sprockets 1 and 2 is substantially an integer multiple of the chain pitch so that the roller of chain 3 is biased to be positioned corresponding to center 02 between the adjacent teeth at sprocket 1, and first tooth 11 is easily engageable with chain 3, resulting in that wide space 3a between outer link plates 31 adjacent to the roller smoothly engages with first tooth 11.

In this condition, since second tooth 12 behind first tooth 11 in the driving rotation direction of sprocket 1 also is an easily-engageable tooth, space 3b between inner link plate 32 behind outer link plate 31 in the traveling direction and adjacent thereto smoothly engages with second tooth 12, thereby quickly shifting chain 3 to sprocket 1. Also, outer link plate 31 behind inner link plate 32 in the traveling direction can reliably engage with third tooth 13 behind second tooth 12. In other words, tooth 13 is easily engageable with chain 3 and first tooth 11 is provided with a chain guide surface 11a, so that chain 3, when shifted from sprocket 2 to sprocket 1, can be displaced reversely to sprocket 2 more than when guide surface 11a is not provided, and correspondingly second tooth 12 is displaced reversely to sprocket 2 and third tooth 13 with respect to second tooth 12, thereby reliably preventing outer link plate 31 from riding on third tooth 13. Also, chain 3 can smoothly engage with third tooth 13 without riding thereon and eliminate sounds generated when engaging with chain 3.

On the other hand, when inner link plate 32 corresponds in position to first tooth 11 when chain 3 is being shifted, space 3b between inner link plates 32 does not engage with first tooth 11, but a space 3a between the next outer link plates 31 positioned behind inner link

plates 32 in the traveling direction (the direction of arrow Y) engages with second tooth 12. In this condition, the next inner link plates 32 positioned behind outer link plates 31 in the traveling direction correspond to third tooth 13. Since third tooth 13 is a speed change tooth, space 3b between inner link plates 32 engages with third tooth 13, whereby chain 3 is quickly shifted to larger diameter sprocket 1.

Alternatively, the multistage sprocket assembly may comprise three or more sprockets and may be used for a crank means at the bicycle.

As is apparent from the above, the present invention has at least one larger diameter sprocket 1 and at least one smaller diameter sprocket 2 assembled in a relationship such that a center 02 between a pair of adjacent teeth at sprocket 1 and a center 01 between a pair of adjacent teeth at sprocket 2 are positioned on a tangent to the chain path. Also, according to the invention, the distance between centers 01 and 02 is substantially an integer multiple of the chain pitch, and a chain guide portion 4 is provided to allow chain 3 to deviate axially outwardly of sprocket 1 at the inside surface thereof facing sprocket 2 and corresponding to the traveling path of chain 3 when traveling between centers 01 and 02, whereby, when chain 3 is shifted from smaller diameter sprocket 2 to larger diameter sprocket 1, the chain can smoothly engage with sprocket 1 and chain guide portion 4 can displace by a predetermined amount axially outwardly of sprocket 1. Hence, the space between outer link plates 31 can reliably engage with the first tooth behind center 02, and also inner link plates 32, even when corresponding to first tooth 11 but not engaging therewith, never rides on first tooth 11, thereby

reliably engaging outer link plates 31 behind inner link plate 32 in the traveling direction. Also, inner link plates 32 behind outer link plates 31 in the traveling direction can reliably engage with third tooth 13 positioned behind second tooth 12 in the driving rotation direction of sprocket 1.

Although several embodiments have been described above, they are merely exemplary of the invention and not to be construed as limiting, the invention being defined solely by the appended claims.

WHAT IS CLAIMED IS:

1. A multistage sprocket assembly for a bicycle, said sprocket assembly comprising:

at least one large diameter sprocket having at its outer periphery a plurality of teeth; and at least one smaller diameter sprocket having at its outer periphery a plurality of teeth smaller in number than said plurality of teeth of said larger diameter sprocket, a pair of adjacent teeth of said larger diameter sprocket having a first center point therebetween and a pair of adjacent teeth of said smaller diameter sprocket having a second center point therebetween, said first center point and said second center point being positioned on a tangent line extending along a traveling path between said smaller diameter sprocket and said larger diameter sprocket of a driving chain in engagement with said smaller diameter sprocket when said chain is being shifted from said smaller diameter sprocket to said larger diameter sprocket, a distance between said first center point and said second center point being substantially an integer multiple of a pitch between adjacent links of said chain, and said larger diameter sprocket comprising chain guide means, provided at its inside surface facing said smaller diameter sprocket and at a position of said larger diameter sprocket corresponding to said traveling path of said chain when traveling between said first center point and said second center point, for allowing said chain to move at said chain guide means farther from said smaller diameter sprocket and closer toward said inside surface of said larger diameter sprocket than at other portions of said larger diameter sprocket.

2. A multistage sprocket assembly according to claim 1, wherein at least two teeth among said plurality of

teeth of said larger diameter sprocket are speed change teeth which include means for facilitating engagement with said chain when said chain is being shifted from said smaller diameter sprocket to said larger diameter sprocket, said speed change teeth including a first tooth positioned behind said first center point in a driving rotation direction of said larger diameter sprocket, all other teeth of said plurality of teeth of said larger diameter sprocket including means for inhibiting engagement thereof with said chain when said chain is being shifted from said smaller diameter sprocket to said larger diameter sprocket.

3. A multistage sprocket assembly according to claim 2, wherein said speed change teeth comprise a first tooth, a second tooth adjacent to and behind said first tooth in said driving rotation direction of said larger diameter sprocket, and a third tooth adjacent to and positioned behind said second tooth in said driving rotation direction of said larger diameter sprocket.

4. A multistage sprocket assembly according to claim 3, wherein said first tooth includes a chain guide surface for guiding said chain in a direction away from said smaller diameter sprocket when said chain is being shifted from said smaller diameter sprocket to said larger diameter sprocket, said second tooth is positioned farther from said smaller diameter sprocket than said first tooth is positioned from said smaller diameter sprocket, and said third tooth is positioned farther from said smaller diameter sprocket than said second tooth is positioned from said smaller diameter sprocket.

5. A multistage sprocket assembly according to claim 1, wherein said chain guide means comprises a chain

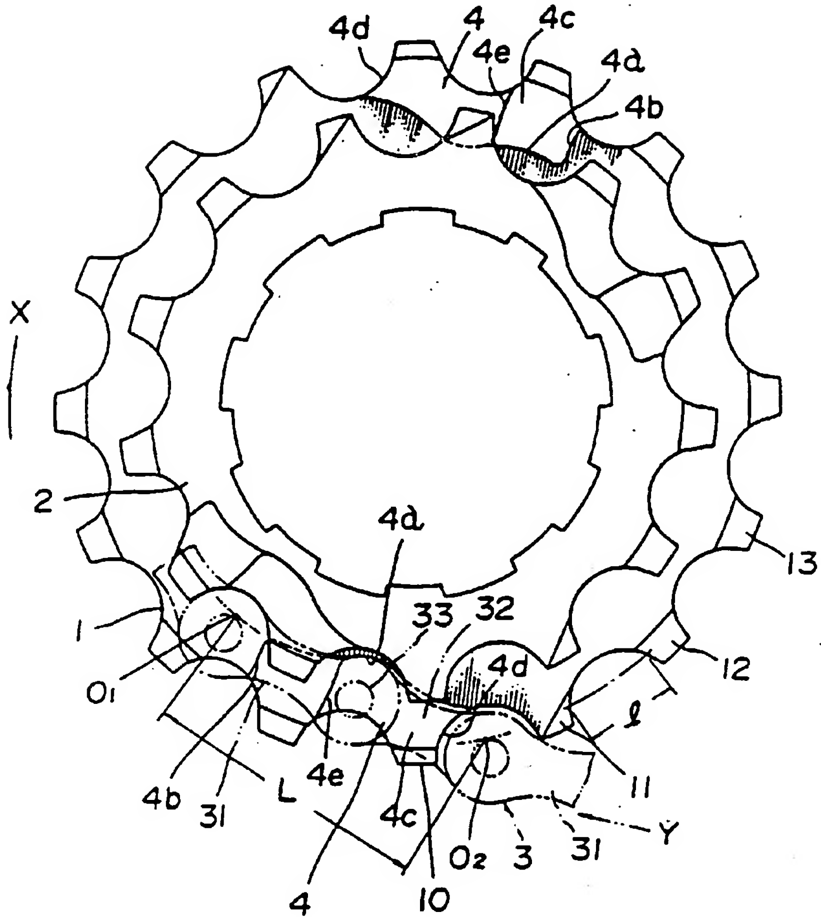
guide portion recessed at said surface of said larger diameter sprocket facing said smaller diameter sprocket, said recess having a sufficient depth at a side of said first center point to prevent an outside link plate of said chain from riding on a tooth positioned behind said first center point in said driving rotation direction of said larger diameter sprocket.

6. A multistage sprocket assembly according to claim 1, wherein said chain guide means comprises a chain guide portion formed of a cutout in said inside surface of said larger diameter sprocket.

ABSTRACT

A multistage sprocket assembly is provided which includes at least one larger diameter sprocket and at least one smaller diameter sprocket assembled in a relationship such that the center point between a pair of adjacent teeth at the larger diameter sprocket and the center point between a pair of adjacent teeth at the smaller diameter sprocket are positioned on a tangent extending along the chain path when the chain is being shifted from the smaller diameter sprocket to the larger diameter sprocket. The distance between both the center points is equal to an integer multiple of the chain pitch. A chain guide portion is provided at the inside surface of the larger diameter sprocket and at a position corresponding to a moving path of a driving chain traveling between the aforesaid center points for allowing the chain to move axially of the sprocket assembly slightly toward the larger diameter sprocket during shifting.

Fig.1



Appendix 1

Fig.2

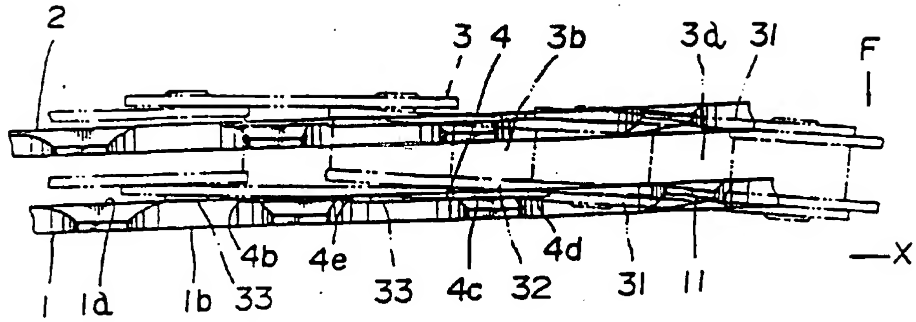
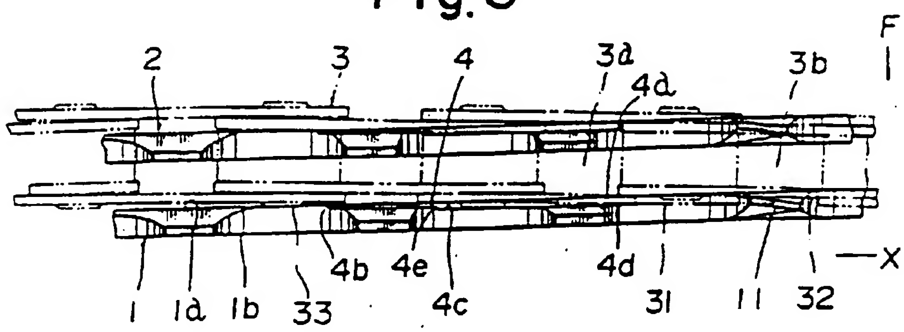


Fig.3



Appendix 1

Fig. 4

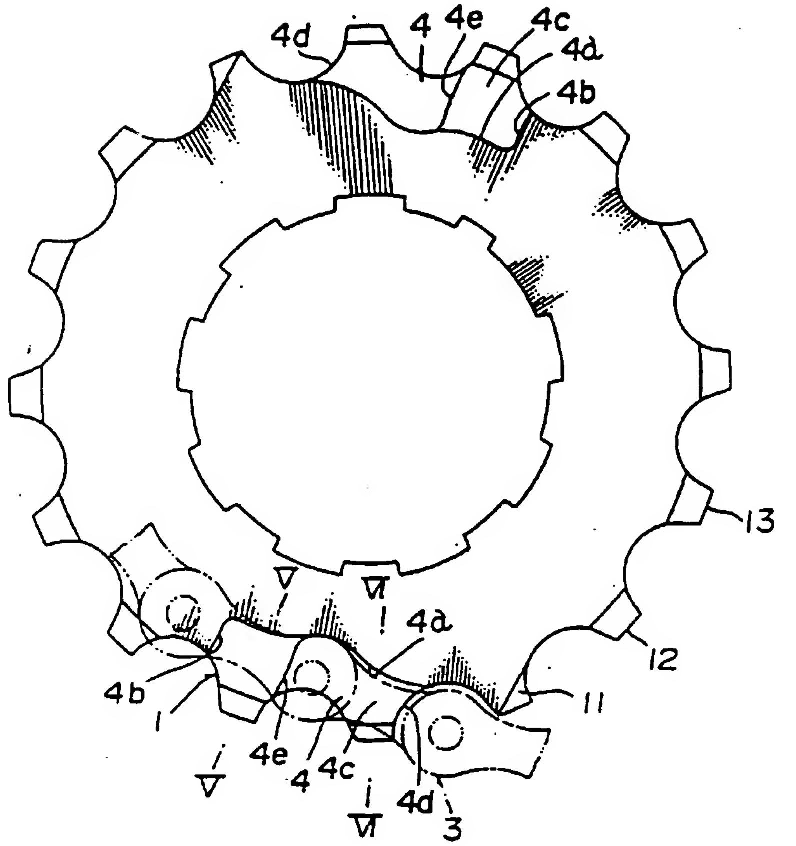


Fig.5

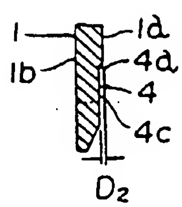


Fig.6

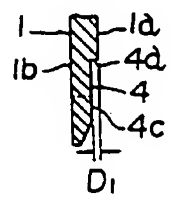
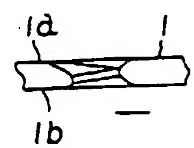


Fig.7



Appendix 1 -

Fig.8

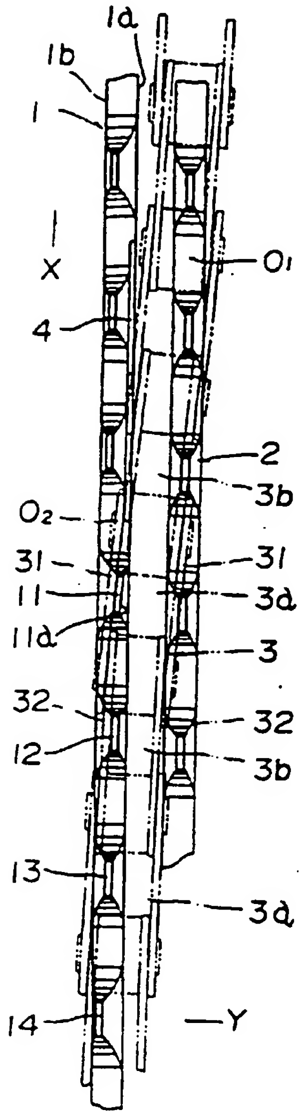
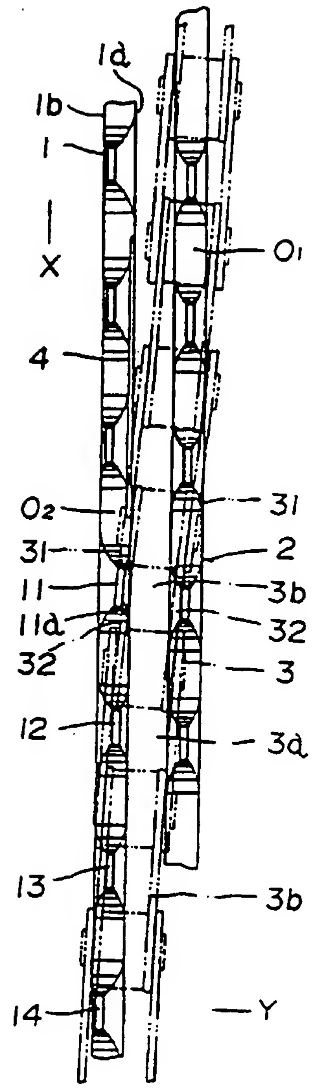


Fig.9



Appendix 1 -

Claims

1. A sprocket cluster for a bicycle comprising:
   a plurality of sprockets coaxially mounted together in an axially fixed position relative to each other, wherein a free space is disposed between a root circle portion of a smaller diameter sprocket and an axially aligned portion of a larger diameter sprocket, and wherein a spacing between each pair of adjacent sprockets is less than or equal to a thickness of at least one of the plurality of sprockets.

2. The sprocket cluster according to Claim 1 wherein the spacing between each pair of adjacent sprockets is less than or equal to the thickness of each of the plurality of sprockets.

3. A sprocket cluster for a bicycle comprising:
   a plurality of sprockets coaxially mounted together in an axially fixed position relative to each other, wherein a free space is disposed between a root circle portion of a smaller diameter sprocket and an axially aligned portion of a larger diameter sprocket, and wherein a spacing between each pair of adjacent sprockets is less than or equal to approximately 2.0 millimeters.

4. The sprocket cluster according to any preceding claim wherein the spacing between each pair of adjacent sprockets is less than or equal to approximately 1.8 millimeters.

5. A sprocket cluster for a bicycle comprising:
   at least ten sprockets coaxially mounted together and forming a first free side sprocket surface facing laterally outwardly and a second free side sprocket surface facing laterally inwardly, wherein a spacing between the first free side sprocket surface and the second free side sprocket surface is less than or equal to approximately 50 millimeters.

6. The sprocket cluster according to Claim 5 wherein the spacing between the first free side sprocket surface and the second free side sprocket surface is less than or equal to approximately 47 millimeters.

7. A multiple sprocket assembly for a bicycle comprising:

   a mounting member having a radial extension;

   a first sprocket formed as one piece with the mounting member and disposed at a radially outward end of the radial extension; and

   a plurality of second sprockets mounted to the radial extension coaxially with the first sprocket.

8. The multiple sprocket assembly according to Claim 7 wherein the mounting member includes a plurality of ledges, wherein each second sprocket is mounted on one of the plurality of ledges

9. The multiple sprocket assembly according to either of Claims 7 or 8 wherein the mounting member includes a boss having an outer lateral side surface, and further comprising a plurality of third sprockets disposed laterally outwardly relative to the outer lateral side surface.

10. The multiple sprocket assembly according to any one of Claims 7 to 9 wherein the mounting member includes a boss having an inner lateral side surface disposed laterally outwardly relative to the first sprocket.

11. The multiple sprocket assembly according to any one of Claims 7 to 10 wherein a spacing between each pair of adjacent second sprockets is less than or equal to a thickness of at least one of the plurality of second sprockets.

12. The multiple sprocket assembly according to Claim 11 wherein the spacing between each pair of adjacent second sprockets is less than or equal to the thickness of each of the plurality of second sprockets.

13. The multiple sprocket assembly according to any of Claims 7 to 12 wherein the mounting member has a plurality of radially extending arms wherein the first sprocket is formed as one piece with the mounting member and is disposed at respective radially outward ends of the plurality of radially extending arms and wherein the plurality of second sprockets are mounted to the plurality of radially extending arms coaxially with the first sprocket.

14. A bicycle hub and sprocket apparatus comprising:

a hub including first and second hub flanges spaced apart from each other;

a sprocket cluster coaxially mounted to the hub in close proximity to the first hub flange, including:

a mounting member having a radial extension;

a plurality of sprockets mounted to the radial extension;

wherein at least one of the plurality of sprockets is positioned laterally inwardly of an outer side surface of the first hub flange.

15. The apparatus according to Claim 14 wherein the plurality of sprockets includes a first sprocket formed as one piece with the mounting member and disposed at a radially outward end of the radial extension.

16. The apparatus according to Claim 15 wherein the mounting member includes a boss having an inner lateral surface disposed laterally outwardly relative to the first sprocket.

17. The apparatus according to any of Claims 14 to 16 wherein the mounting member includes a plurality of ledges, wherein the plurality of sprockets include a plurality of second sprockets, and wherein each second sprocket is mounted on one of the plurality of ledges.

18. The apparatus according to Claim 17 wherein the mounting member includes a boss having an outer lateral side surface, and wherein the plurality of sprockets includes a plurality of third sprockets disposed laterally outwardly relative to the outer lateral side surface.

19. The apparatus according to any one of Claims 14 to 18 wherein a spacing between each pair of adjacent sprockets is less than or equal to a thickness of at least one of the plurality of sprockets.

20. The apparatus according to Claim 19 wherein the spacing between each pair of adjacent sprockets is less than or equal to the thickness of each of the plurality of sprockets.

21. The apparatus according to any one of Claims 14 to 20 wherein the mounting member has a plurality of radially extending arms, and wherein the plurality of sprockets are mounted to the plurality of radially extending arms.

22. A chain and a sprocket cluster for use in a bicycle transmission, wherein the chain comprises:

a plurality of intermediate links;

a plurality of pairs of outer links;

a plurality of fasteners, wherein each fastener connects an end of one of the plurality of intermediate links between a corresponding pair of outer links so that the plurality of intermediate links alternate with the plurality of pairs of outer links;

wherein each intermediate link defines a recess between each end thereof for receiving a sprocket tooth therein, the recess extending between the fasteners at each end of the intermediate link; and

wherein the sprocket cluster comprises:

a plurality of sprockets coaxially mounted together, each sprocket including a plurality of teeth for engaging the chain so that a sprocket tooth extends into the recess of each intermediate link engaging the sprocket.

23. The apparatus according to Claim 22 wherein a spacing between each pair of adjacent sprockets is less than or equal to a thickness of at least one of the plurality of sprockets.

24. The apparatus according to Claim 23 wherein the spacing between each pair of adjacent sprockets is less than

or equal to the thickness of each of the plurality of sprockets.

25. The apparatus according to any one of Claims 22 to 24 wherein a spacing between each pair of adjacent sprockets is less than or equal to approximately 2.0 millimeters.

26. The apparatus according to any one of Claims 22 to 25 wherein the plurality of sprockets comprises at least ten sprockets.

27. The apparatus according to any one of Claims 22 to 26 wherein the plurality of sprockets are coaxially mounted together and form a first free side sprocket surface facing laterally outwardly and a second free side sprocket surface facing laterally inwardly, wherein a spacing between the first free side sprocket surface and the second free side sprocket surface is less than or equal to approximately 50 millimeters.

FIG.1 (PRIOR ART)

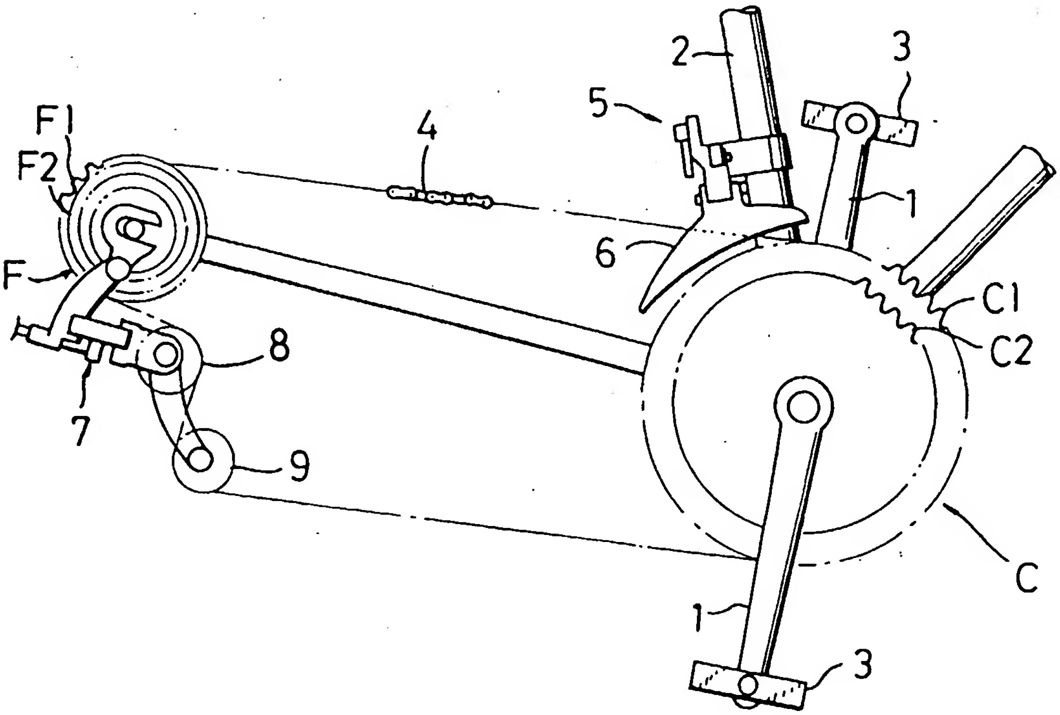


FIG. 2(PRIOR ART)

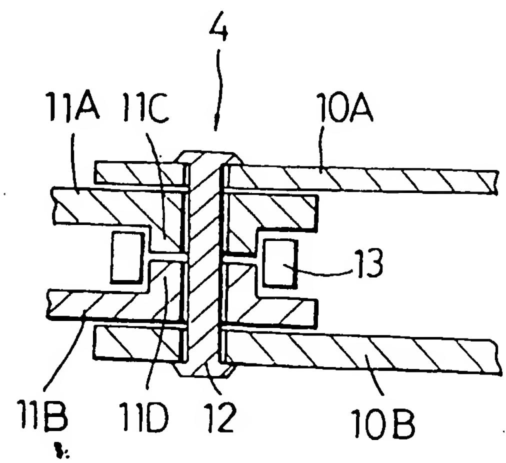


FIG.3

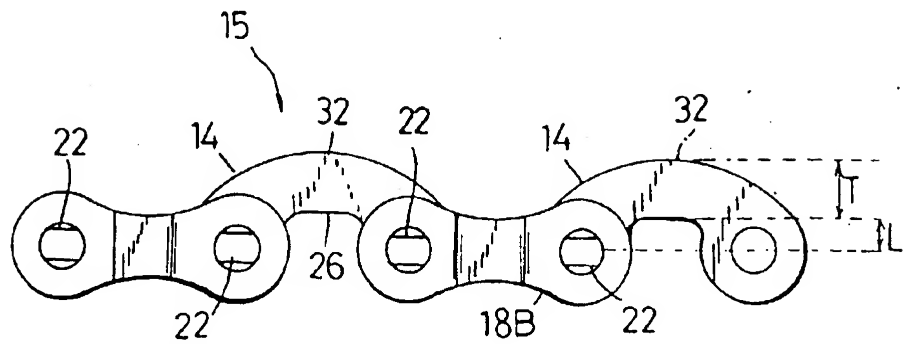


FIG.4

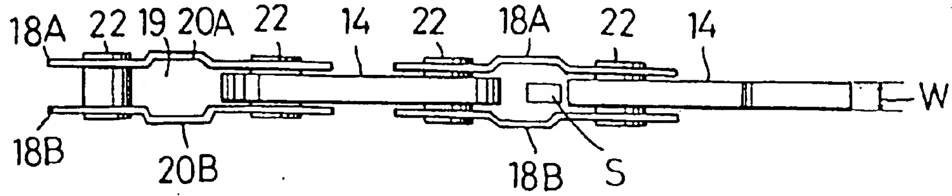


FIG.5

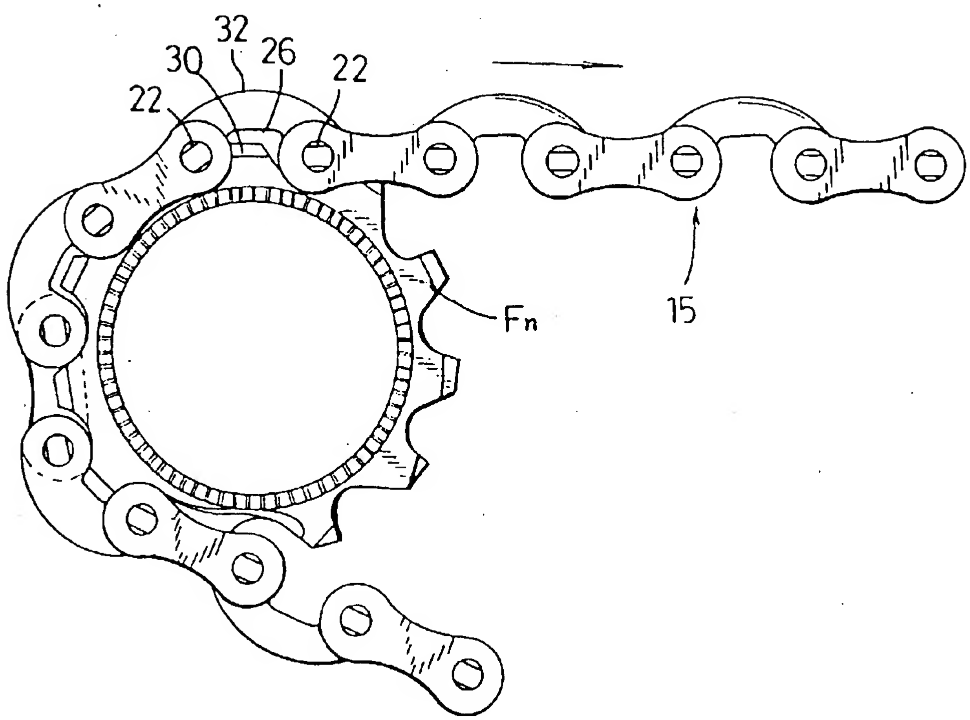


FIG.6

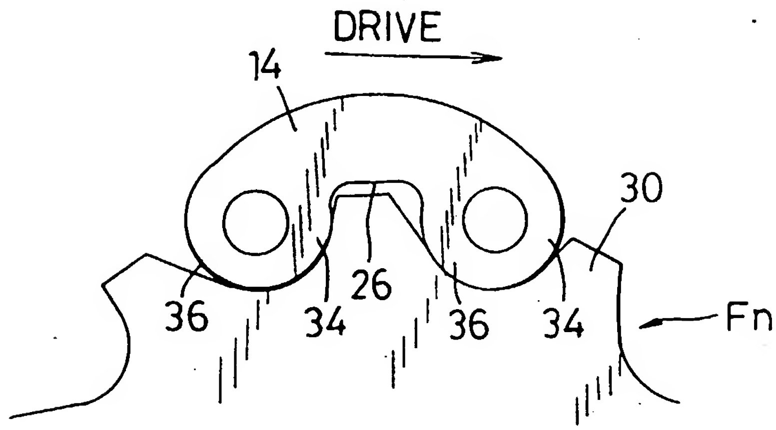


FIG.7

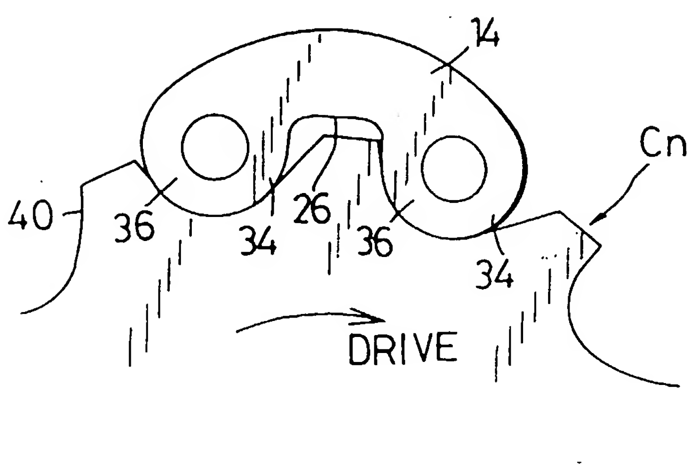


FIG. 8

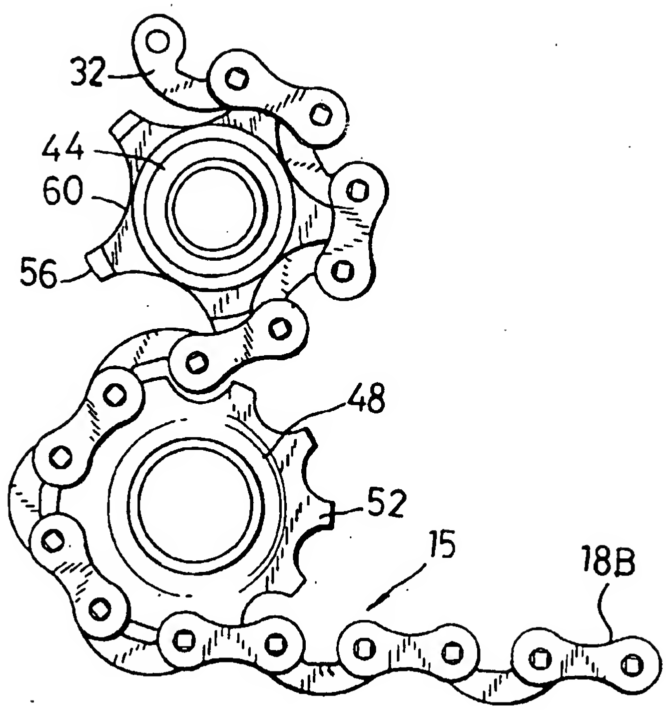


FIG. 9

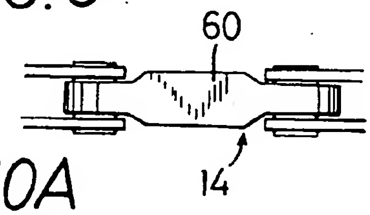


FIG.10A

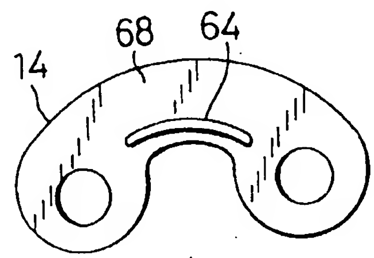


FIG.10B

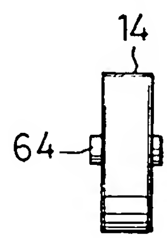


FIG.11

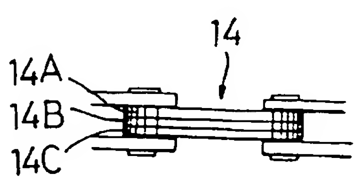
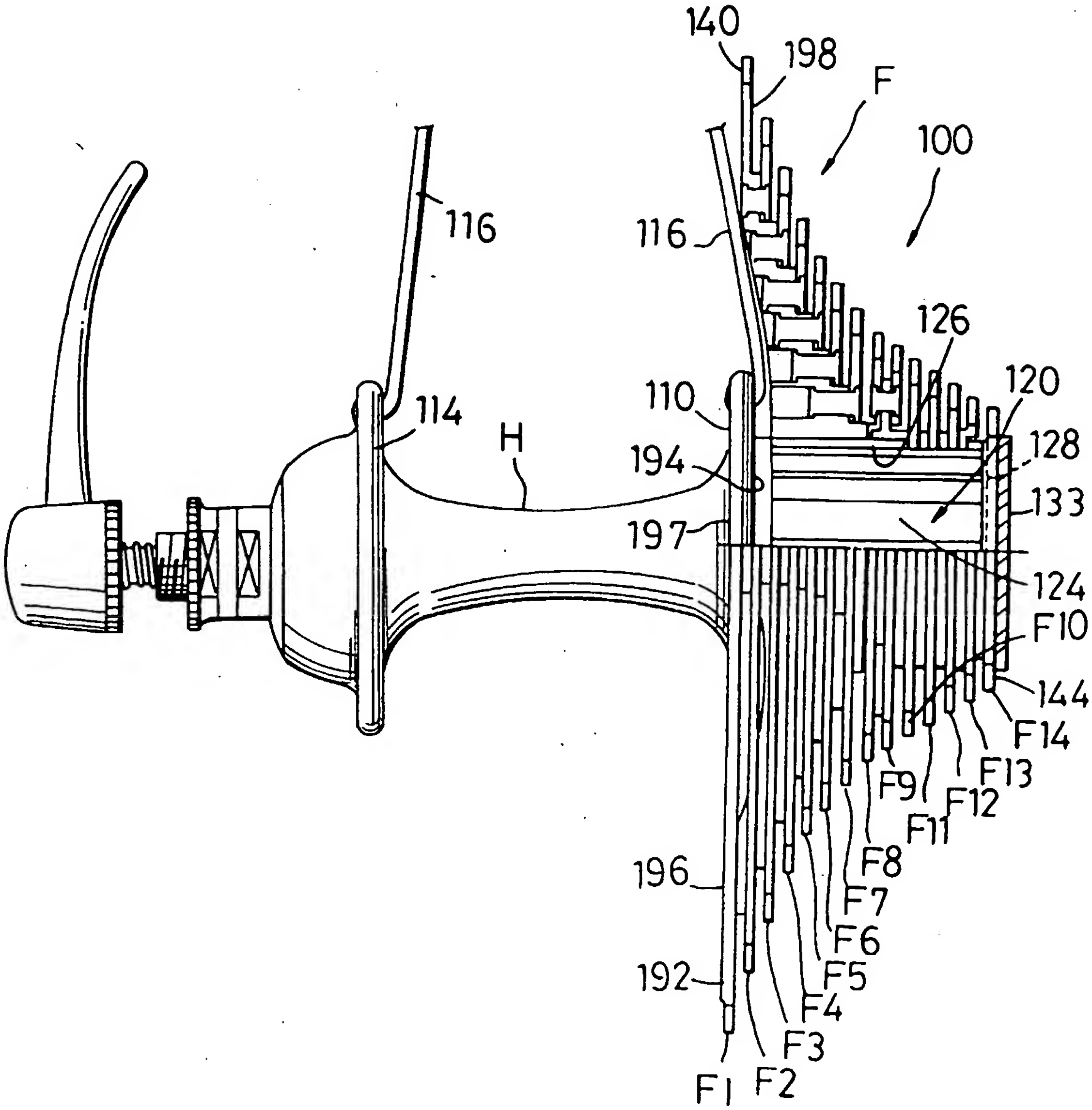


FIG.12



140
198
F
100
116
116
126
120
110
114
H
128
194
133
197
124
F10
144
F14
F13
F12
F11
F9
F8
F7
F6
F5
F4
F3
F2
F1
196
192

FIG.13

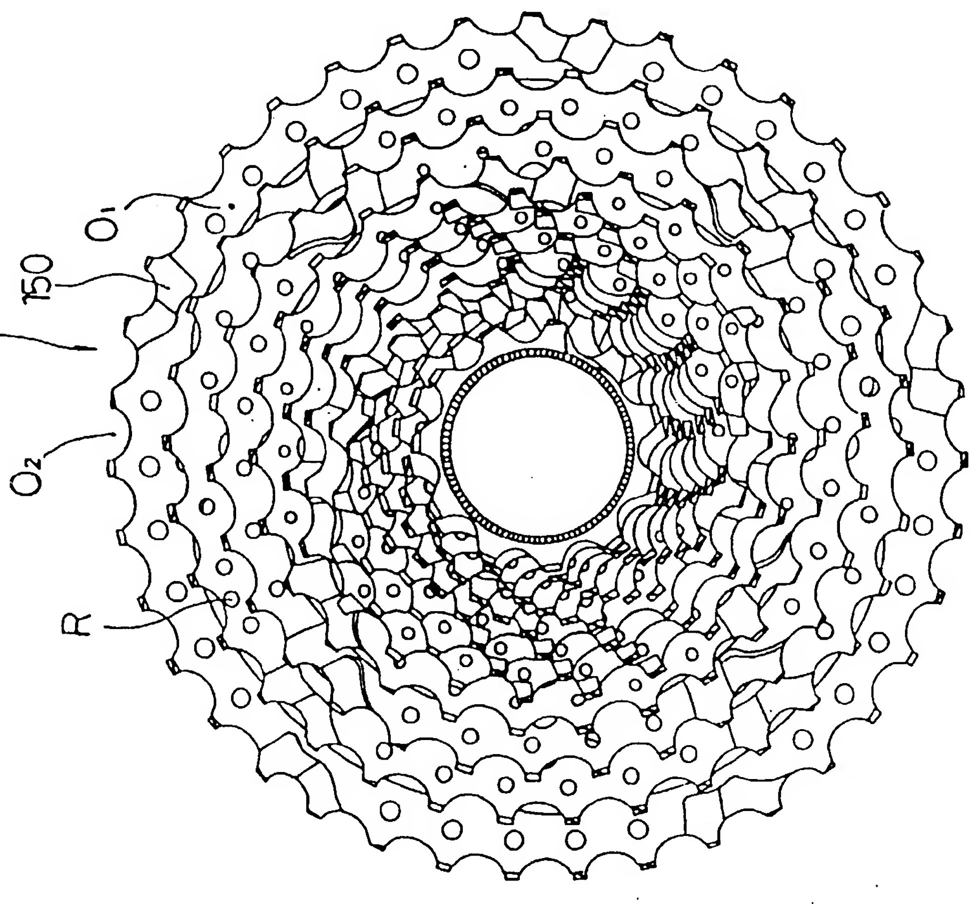
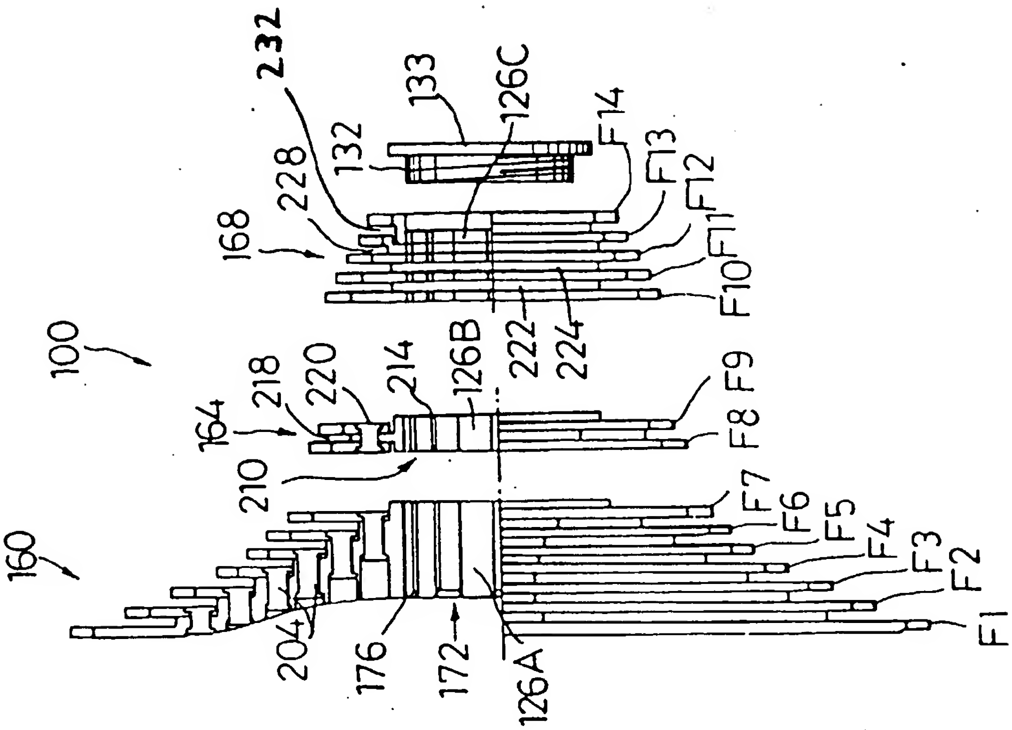

R
O2
100
150
O1

FIG.14


100
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232
133
132
228
126C
218
220
214
126B
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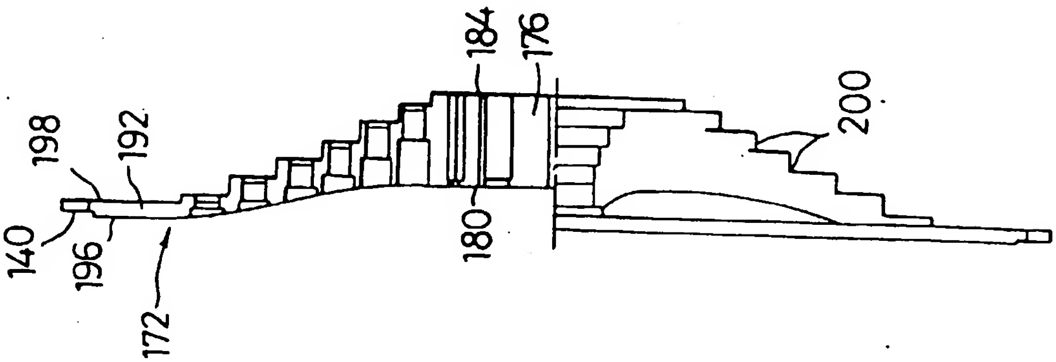
222
224
204
176
172
126A
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
F11
F12
F13
F14

FIG.16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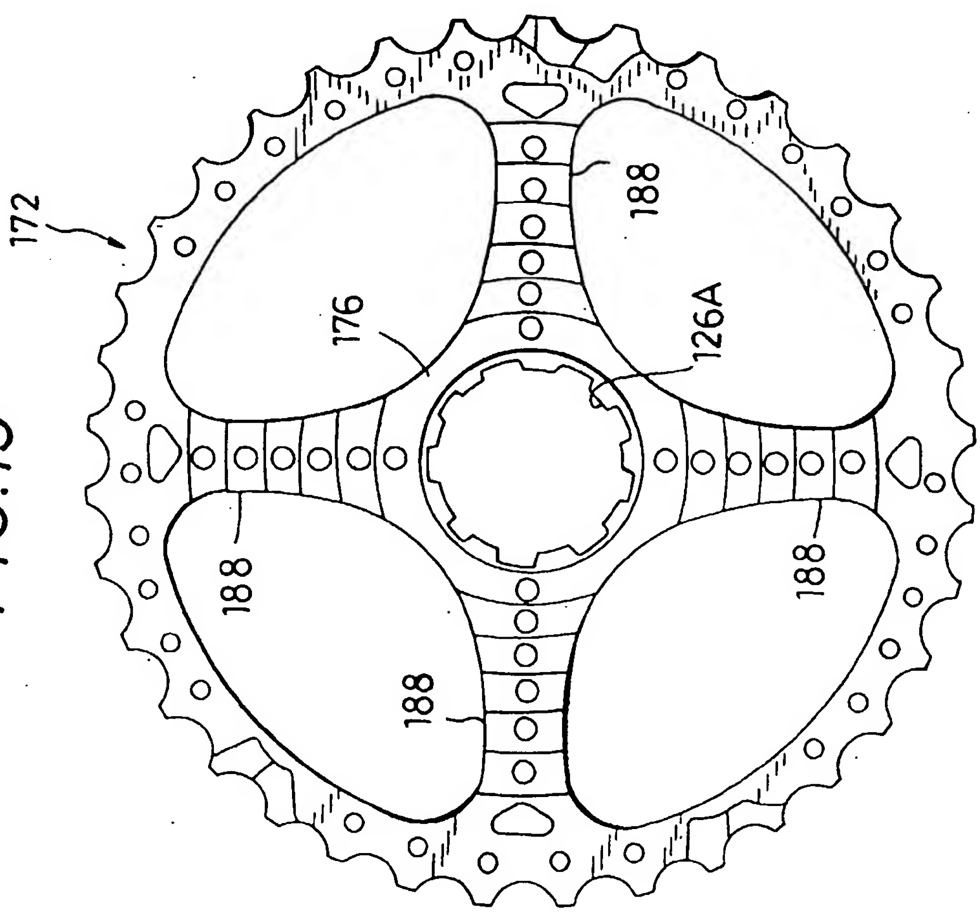
196
198
192
172
180
184
176
200

FIG.15


172
176
188
126A
188
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188
188